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## THE HORIZON OF THE MARINE JURASSIC OF UTAH

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Some time ago the writer, during the course of a reconnaissance in southern Utah, made a small collection of fossils from marine beds near the base of what is quite probably the McElmo formation. These were collected about a half-mile southwest of Teasdale (Teardale on the Fish Lake reconnaissance topographic sheet of the United States Geological Survey), probably in section 20,



FIG. 1.—Contact of thin-bedded marine Jurassic limestone on white cross-bedded sandstone of La Plata group. One-half mile southwest of Teasdale, Utah. (Contact at black line.)

T. 29 S., R. 4 E. At the point where the fossils were collected the exposures consisted of about 100 feet of white massive cross-bedded sandstone, taken to be the top of the La Plata, above which were a few feet of thin-bedded shaly limestones, constituting the fossil-bearing horizon (Fig. 1). On account of the inaccessibility of the slopes and the very limited time available, no detailed section was measured at this point.

The writer, however, measured a detailed section near the mouth of Cedar Canyon, about 6 miles due east of Loa, along the west base of Thousand Lake Mountain, just east of the fault that is reported by Dutton<sup>1</sup> to form the west scarp of that mountain. The section follows. Figure 2 shows the beds in the upper part of the section.

## SECTION AT MOUTH OF CEDAR CANYON, 6 MILES EAST OF LOA

No.	Feet	
29	...	Talus from cliffs of overlying lava.
28	375+	Alternating green and red sandy shales with occasional gypsum beds.
27	40	Covered slope, abundant gypsum fragments, probably gypsum.
26	100	Gypsum with thin clay seams.
25	10	Drab shale, more massive than No. 24, forms ledge.
24	22	Thin-bedded drab shale in slope.
23	50	Calcareous gray shale, in cliff, weathers with rounded surfaces.
22	3	Slightly argillaceous notably cross-bedded limestone.
21	11	Covered slope; digging shows red and gray clay.
20	5	Dense thin-bedded calcareous shale or argillaceous limestone, forms bench.
19	32	Thin-bedded calcareous shale or argillaceous limestone, forms slopes.
18	1	Brown, sandy, porous limestone.
17	4	Greenish gypsum.
16	5	Green argillaceous sandstone.
15	5	Covered slope.
14	30	Gypsum.
13	25	Covered slope, probably red shale.
12	1	Gray limestone.
11	3	Thin-bedded drab shale.
10	5	Very light gray limestone.
9	16	Fairly well-bedded greenish, argillaceous sandstone.
8	10	Covered, probably shale.
7	20	Fissile red-brown shale, in a bench with marked re-entrant angles.
6	36	Thin-bedded drab shale.
5	6	Gray limestone, with thin shale near middle, fossiliferous.
4	1	Greenish sandy shale.
3	8	Thin-bedded drab limestone, slightly cross-bedded.
2	35	Tan-colored, well-bedded argillaceous sandstone.
1	130	White cross-bedded sandstone.
<hr/>		
989		

<sup>1</sup> C. E. Dutton, "Report on the Geology of the High Plateaus of Utah," 1880.

In this section, Nos. 1 and probably 2 are thought to be La Plata. No. 6 is almost certainly the same horizon from which the Teasdale collection of fossils was made. It is perhaps 10 miles or less from Cedar Canyon southeast to Teasdale.

The fossils were submitted to Dr. T. W. Stanton, of the United States Geological Survey, who lists them as follows: *Pentacrinus whitei* Clark; *Camptonectes platessiformis* White; *Trigonia quadrangularis* Hall and Whitfield; small undescribed gastropods.

Dr. Stanton<sup>1</sup> says, "These fossils show close relationship with the Sundance fauna, but there have been different opinions concerning the exact position of the bed containing them with reference



FIG. 2.—White, red, and green sandy shale and gypsum above marine Jurassic limestone, head of Cedar Canyon, 6 miles east of Loa, on west slope of Thousand Lake Mountain, Utah.

to the La Plata. C. T. Lupton, who observed the same fossiliferous horizon, included it in the McElmo and agreed with you in considering the top of the underlying sandstone as the top of the La Plata.<sup>2</sup> W. B. Emery, who has had the advantage of field work in north-eastern Arizona and northwestern New Mexico as well as southern Utah, thinks that this fossiliferous Jurassic limestone represents the Todilto formation which is near the middle of the La Plata group according to Gregory's stratigraphy in *Professional Paper* 93.

<sup>1</sup> Personal communication.

<sup>2</sup> *U.S. Geol. Surv., Bull.* 541, p. 125.

You will find his discussion of the section in a paper on the Green River Desert section, Utah."<sup>1</sup>

The earliest reference to fossiliferous beds at this horizon in this locality that has come under the notice of the writer is by Gilbert,<sup>2</sup> who, in describing the Flaming Gorge formation, says: "In the immediate vicinity of the Henry Mountains it varies little except in color from summit to base, but in other localities not far distant it is interrupted near the base by thick beds of gypsum and gypsiferous clays, and by a sectile, fossiliferous limestone." Gilbert's Vermilion Cliff and Gray Cliff sandstones in this locality have been generally supposed to represent the two major divisions of the La Plata group, described by Gregory<sup>3</sup> in the Navajo country as the Wingate and Navajo sandstones respectively; and although Cross<sup>4</sup> interprets the Vermilion Cliff of the older writers to be the upper part, at least, of the present Dolores formation, anyone who has studied the detailed section given by Gilbert in the identical localities from which he describes them cannot help being certain that his upper Shinarump shales are Dolores, and that his Vermilion Cliff sandstone includes the base of the La Plata and probably does not include any of the Dolores. Likewise Gilbert's Gray Cliff is La Plata, and his Flaming Gorge is in part, and probably in totality, the equivalent of the McElmo formation of more recent writers.

The present writer has studied these formations in some detail in the region described by Gilbert, particularly along Water Pocket Canyon and on the Water Pocket Flexure. Here the total thickness of the Vermilion Cliff and Gray Cliff together is estimated (not measured) as not less than 1,500 feet. Near the contact between them is about 100 feet of shaly red sandstone, less resistant than the material above and below, and this is believed by the writer to correspond to Gregory's Todilto beds. The general

<sup>1</sup> *Amer. Jour. Sci.*, XLVI (October, 1918), 551-57.

<sup>2</sup> G. K. Gilbert, *Report on the Geology of the Henry Mountains*, 1880.

<sup>3</sup> H. E. Gregory, "Geology of the Navajo Country," *U.S. Geol. Surv., Prof. Paper* 93, 1917.

<sup>4</sup> Whitman Cross, "Stratigraphic Results of a Reconnaissance in Western Colorado and Eastern Utah," *Jour. Geol.*, XV (1907), 634-79.

nature of these beds is best brought out by the illustrations. Figure 3 shows a sheer wall of the Vermilion Cliff; Figure 4 illustrates one of the characteristic arches developed by the curved lamination of the same formation, and, in addition, shows the over-

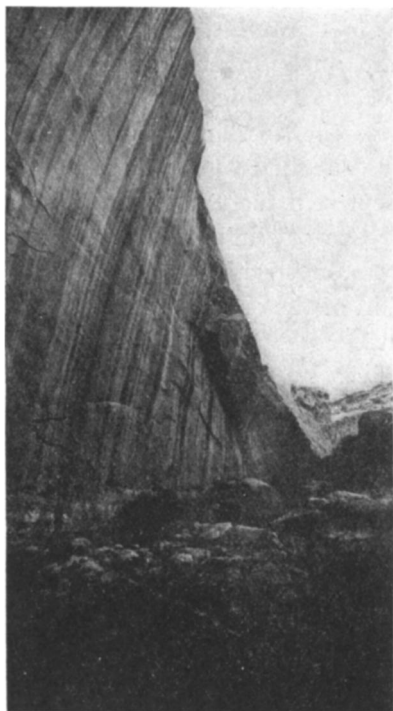


FIG. 3.—Cliff of basal La Plata sandstone (Vermilion Cliff), in Mule Twist Canyon, Water Pocket Flexure, near Henry Mountains, Utah. (Vertical lines are not bedding, but probably water streaking.)

lying thin, shaly red sandstones of the supposed Todilto. In Figure 5 the same thin-bedded red sandstone is shown at the base, capped by a remarkable wall of the upper, or Gray Cliff, formation. In the foreground of Figure 6 is shown a low cliff of the Moenkopi capped with Shinarump conglomerate; above that, slopes exposing 500 to 600 feet of Dolores or Chinle shales (upper Shinarump shale); in the middle distance massive cliffs of the lower La Plata or Vermilion (Wingate?); next above are slightly thinner beds capping the cliff (probably Todilto); and finally in the background the amazing domes of the upper La Plata or Gray Cliff (Navajo?), which give the name of Capitol Wash to the canyon. Figure 7 also shows the three divisions of the La Plata here, the Vermilion Cliff below (the sheer wall), then the

more shaly beds, and finally the Gray Cliff sandstone above with its characteristic domes.

Near the base of the Flaming Gorge at this point are also massive tan sandstones identical with the La Plata (Figs. 8, 9, 10) and only distinguished from it by their position well above both divisions of the La Plata, as just described. In Water Pocket

Canyon the basal Flaming Gorge contains heavy gypsum beds occupying a position below this tan sandstone and above the two-fold La Plata sandstones. In this locality the fossiliferous limestones were not noted by the writer, but they are reported by Gilbert<sup>1</sup> west of Masuk Plateau. The localities in Water Pocket Canyon are perhaps 30 or 40 miles southeast of where the Teasdale collection was made.

In the Water Pocket Canyon locality the Flaming Gorge beds supposed to be McElmo are directly overlain by sandstones that



FIG. 4.—Lower La Plata (Vermilion Cliff) sandstone, with characteristic arch, overlain by thin-bedded red sandy shale (Todilto?) in Mule Twist Canyon, Water Pocket Flexure, near Henry Mountains, Utah.

grade up into typical Mancos shale. From these sandstone beds the writer collected the following fossils along Bitter Creek Divide. Identifications were made by Dr. Stanton, who says:<sup>2</sup> "The collection from the sandstone near base of Mancos shale in Water Pocket Canyon yielded a number of species that are known to be characteristic of the sandstones in the lower part of the Mancos, as follows: *Ostrea prudentia* White; *Exogyra columbella* Meek; *Exogyra* sp., related to *E. laeviuscula* Roemer;\* *Exogyra* sp., related to *E. ponderosa* Roemer;\* *Gryphaea newberryi* Stanton;

<sup>1</sup> G. K. Gilbert, *op. cit.*, Fig. 2.

<sup>2</sup> Personal communication.

\*"White identified these two Texas species in collections from southeastern Utah and I repeated his descriptions and figures under the same names in *Bull. 106* but I now think them to be probably distinct."

*Plicatula hydrotheca* White; *Camptonectes platessa* White; *Astarte?* sp.; *Cardium trite* White; *Liopistha* (*Psilomya*) *elongata* Stanton."

This should serve to fix the Flaming Gorge, which is next below these sandstones, as at least in part McElmo, and the writer has shown, in the foregoing, that it lies above a sandstone with two definite divisions, believed to correspond to the La Plata.

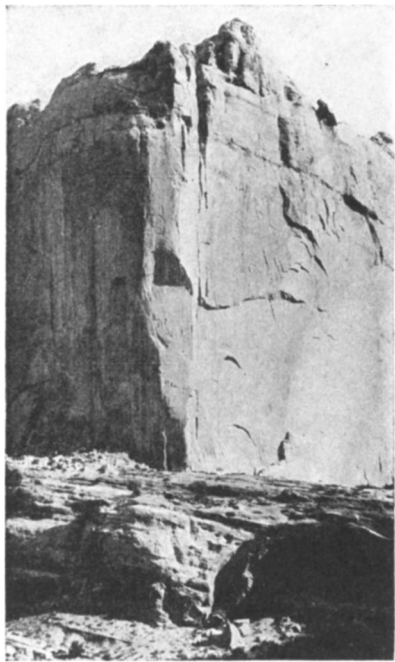


FIG. 5.—Thin-bedded red sandy shale (Todilto?) capped with La Plata (Gray Cliff) sandstone, Mule Twist Canyon, Water Pocket Flexure, near Henry Mountains, Utah.

Unfortunately, at the point where the fossils were collected, the relations so plain in Water Pocket Canyon could not be seen, partly because of faulting and partly because of burial by lavas. However, there is but little doubt in the writer's mind that the Jurassic fossils were found in beds below typical McElmo and above the top of the La Plata. He believes that the McElmo formation is in its upper part equivalent to the Morrison, and that the lower beds, apparently equivalent to the Sundance of Wyoming, lie above the top of the true La Plata (Table I).

This is in marked contrast to the conclusions of Emery,<sup>1</sup> who considers that the Gray and Vermilion Cliff sandstones

are both Wingate, that the fossiliferous gypsum-bearing beds of the writer's section are Todilto (middle La Plata), and that the sandstones placed in the McElmo by the writer are Navajo. As near as the writer can judge, Emery's chief reason for so believing is the lithologic similarity of the limestones of the type Todilto

<sup>1</sup> W. B. Emery, "The Green River Desert Section, Utah," *Amer. Jour. of Sci.*, XLVI (1918), 551-77.



TABLE I  
CORRELATION TABLE\*

Age	Gregory Navajo Country	Gilbert Henry Mountains†	Dake Present Paper	Emery Green River Desert	Cross Interpretation of Powell	Lupton Green River Oil Field
Cretaceous or Jurassic	Dakota sandstone	Henry's Fork group (in part)	Dakota (locally absent) Upper McElmo	Dakota	Dakota	Dakota
	McElmo formation	Flaming Gorge group	Salt Wash member	Upper McElmo	Flaming Gorge group	Upper McElmo
			Lower McElmo (Sundance?)	Salt Wash member Navajo sandstone† Todilto formation		Salt Wash member Lower McElmo
Jurassic	Navajo sandstone	Gray Cliff sandstone	Navajo sandstone	La Plata Group	White Cliff sandstone	La Plata sandstone
	Todilto formation	present, not differentiated	Todilto shaly sandstone			
	Wingate sandstone	Vermilion Cliff sandstone	Wingate sandstone			
Triassic	Chinle formation	Shinarump Group	Dolores formation	Chinle formation	Vermilion Cliff	Shinarump Group
	Shinarump conglomerate	Shinarump conglomerate	Shinarump conglomerate	Shinarump conglomerate	Upper Shinarump (Dolores)§	
	DeChelly sandstone	Shinarump division "c"	Moenkopi	Absent	Shinarump conglomerate	
Permian (?)	Moenkopi	Aubrey group	Kaibab limestone	Moenkopi	Lower Shinarump (Moenkopi)	
Pennsylvanian	Undifferentiated Pennsylvanian		Coconino sandstone	Pennsylvanian (?)	Aubrey group	

\* Dotted lines indicate reported unconformities.

† Gilbert classes all formations between the Aubrey group and the Henry's Fork conglomerate as Jura-trias.

‡ Todilto and Navajo, as recognized by Emery, are considered by him to be Jurassic.

§ Powell classed the entire Shinarump group as Triassic.

with the fossiliferous horizons here described, and the fact that the Todilto seems to be thickening to the northwest from the type area.

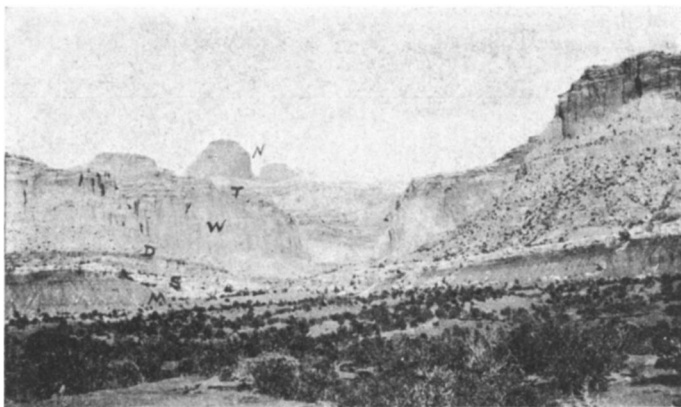


FIG. 6.—Looking into Capitol Wash, on road between Fruita and Notom, Utah. (M = Moenkopi, S = Shinarump, D = Dolores, W = La Plata [Wingate? or Vermilion Cliff], T = La Plata [Todilto?], N = La Plata [Navajo? or Gray Cliff]).



FIG. 7.—Dirty Devil Canyon, Fruita, Utah. Slope at base is Dolores, and the cliffs show three divisions of the La Plata.

Lee<sup>1</sup> comes to conclusions identical with those of Emery and cites many instances in southern Colorado and northern New

<sup>1</sup> W. T. Lee, "Early Mesozoic Physiography of the Southern Rocky Mountains," *Smithsonian Misc. Coll.*, LXIX, No. 4 (1918).

Mexico of the occurrence of limestones and gypsum above a sandstone which he calls repeatedly lower La Plata, or Wingate. The limestones and gypsum are correlated by him with the Todilto or



FIG. 8.—Flaming Gorge (McElmo?) in Water Pocket Canyon, near Henry Mountains, Utah. The knobs of sandstone in the foreground overlie gypsum beds and are part of what Emery correlates as Navajo.



*Photo by L. J. Zoller*

FIG. 9.—Detail of sandstone beds of McElmo shown in Fig. 8 above

middle La Plata. In many of the sections referred to by Lee no sandstone at all is mentioned above the limestones and gypsum. In a few an overlying sandstone is described as probably upper La Plata or Navajo, but at no point does it seem, from his descriptions, to closely resemble typical Navajo.

The writer opposes the conclusions of Emery and Lee on the following grounds:

1. There are, at several other horizons in the La Plata, limestone lenses of character almost absolutely similar to the Todilto with which, on lithologic grounds alone, these fossiliferous beds might quite as well be correlated.

2. The limestones of the Todilto and all the other limestones of the La Plata are apparently absolutely non-fossiliferous, while these beds are packed with fossils.

3. As described by Gregory the Todilto is not a gypsum-bearing formation. On the other hand, the McElmo, where



*Photo by L. J. Zoller*

FIG. 10.—McElmo gypsiferous sandstone and shale, Water Pocket Canyon, Utah. These beds lie above the gypsum beds in dispute, and are considered Navajo by Emery.

definitely known to overlie true Navajo, though it does not carry gypsum beds, is repeatedly reported as highly gypsiferous. Gypsum is also an abundant constituent of the fossiliferous series in question. In a personal letter Dr. Stanton called the writer's attention to the fact that the section in question differed from typical McElmo in its numerous gypsum beds. The criticism applies even more positively in comparisons with the non-gypsiferous Todilto. If, as Lee suggests, the Todilto represents the fringe of the marine fossiliferous beds, along embayments where conditions were unfavorable to marine life, the gypsum-forming conditions should surely be presumed to persist into the Todilto area, a feature of the Todilto that Gregory does not mention.

4. That portion of the Flaming Gorge described by Emery as the Navajo is lithologically very unlike the type Navajo. Among these dissimilarities may be mentioned the presence of much shale and considerable gypsum in the Navajo as described by Emery, and their conspicuous absence in the Navajo of Gregory. Furthermore, Gregory describes much limestone as an almost universal characteristic near the top of the Navajo sandstone in its type region. The Navajo of Emery is apparently quite without such limestones.

5. According to Gregory, greenish tints prevail in the base of the McElmo. The basal part of the section measured by the writer also shows many greenish beds.

6. In the section measured by the writer, totaling 989 feet, in which only the lower 165 feet are clearly La Plata, there are 824 feet of beds, among which it is almost impossible to draw any boundary. They are certainly not all Todilto, or else the Todilto has thickened most enormously in this section. If they are in part Navajo, as must be the case, under Emery's conclusion, then the Navajo here grades inseparably into Todilto.

7. The McElmo, in Gregory's report, is described as extremely variable, but as prevailing sandy, with many intricately cross-bedded sandstone members, a description which fits well the characteristics of the supposed Navajo of Emery's paper.

8. If the basal part of the Flaming Gorge be considered as Todilto and Navajo, the total thickness of the La Plata group in the Water Pocket Canyon region will approximate 2,500 feet, which represents at least unusual thickening of the formation.

9. The old original classification by Gilbert represents a group of lithologic units with much more natural physical boundaries, at least in the area studied by the writer, than do those presented by Emery. In justice it must be said, however, that the writer has not seen the localities described in Emery's paper. His own section was measured about midway between the area studied by Emery and the Water Pocket Canyon, and he has studied the formations south but not north of that point.

10. The gypsiferous beds of northern New Mexico, so frequently mentioned by Lee, do not appear to be overlain by any beds that

can with confidence be referred to the Navajo. The sandy beds which he describes as occurring above the gypsum fit more closely Gregory's description of the sandstones above typical Navajo, being those considered by Gregory to constitute the McElmo. This discrepancy could be brought about either by a mistake in the identity of the sandstones called Wingate below the gypsum beds, or by the absence of any true Navajo, which condition would allow the gypsum beds at the base of the McElmo to rest directly on Wingate or Todilto.

From an extensive personal survey of these formations over a region that includes the Water Pocket Canyon, Dirty Devil Canyon, the Moab Valley, the Big Indian Uplift, the San Juan Uplift, the Fort Defiance Uplift, and the Zuni Uplift, the writer is reasonably familiar with the lithologic variations of these formations, and in view of the facts presented he is forced to the conclusion that these marine Jurassic beds are not the equivalent of the Todilto, but that they are above the Navajo sandstone.

Whether or not they are a part of the true McElmo is another matter. The writer is quite in accord with Emery in believing that a pronounced break occurs at the base of the Salt Wash conglomeratic sandstone. A similar break, with heavy conglomeratic beds, was noted by the writer at the Sundance-Morrison contact in the valley of the south fork of Shoshone River, Wyoming. The following is quoted from the unpublished manuscript of a bulletin on that region prepared by the writer for the Wyoming State Geological Survey: "At several points, particularly near the southeast corner of section 19, T. 51 N., R. 103 W., there lies between typical Sundance and typical Morrison from 5 to 20 feet of coarse pebbly sandstone. The pebbles are all small, mostly less than one-fourth inch in diameter, and consist of gray shale, gray sandstone, black chert, and quartz, mostly well worn and rounded." A break at this horizon, of great importance, is considered probable by Schuchert.<sup>1</sup>

This break, if sufficiently widespread, might well justify the separation of the beds below the Salt Wash member as a distinct formation, equivalent to the Sundance.

<sup>1</sup> Charles Schuchert, "Age of the American Morrison and East African Tendaguru Formations," *Bull. Geol. Soc. America*, XXIX (1918), 245-80.